BNL 200 MeV H^- Transport and Injection

D. Raparia and Y. Y. Lee
Brookhaven National Laboratory

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H^- Transport and Injection Mini-Workshop

OUTLINE

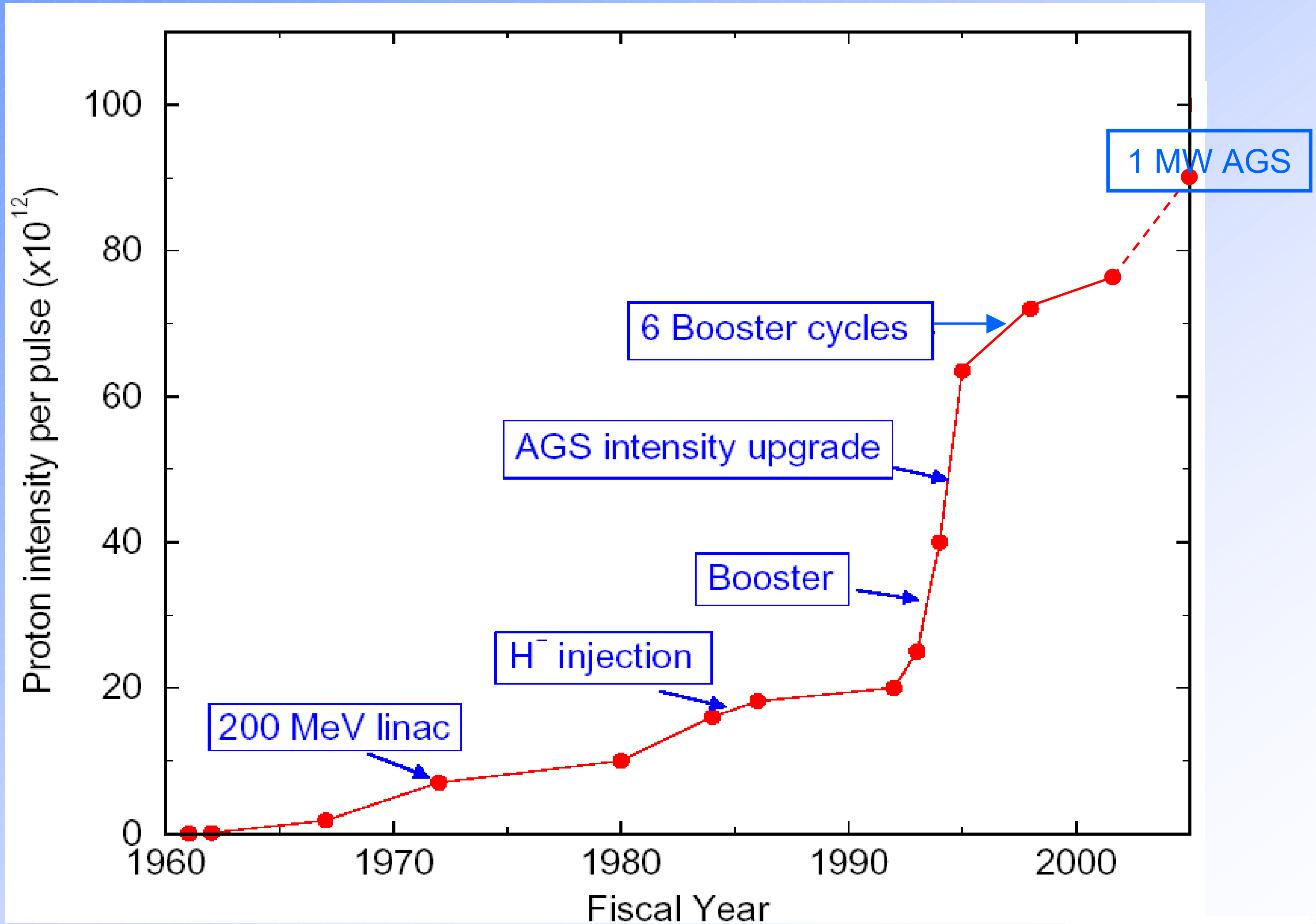
- Introduction
- Transport line
- Injection system
- Beam loss
- Conclusion

Acknowledgements

J. Alessi, K. Brown, YY Lee, K. Zeno,


PHOBOS
10:00 o'clock
12:00 o'clock
BRAHMS & PP2PP ($\vec{p}$)
2:00 o'clock
RHIC
4:00 o'clock
PHENIX($\vec{p}$)
8:00 o'clock
STAR ($\vec{p}$)
6:00 o'clock
NASA - BAF
μ g-2
HEP/NP(p)
LINAC
BOOSTER
AGS
TANDEMS

AGS Intensity History



LINAC Beam Parameters

■ Final Energy	200 MeV
■ Peak Current	30-40 mA
■ Repetition Rate	4 pulses/AGS pulse(7.5 Hz)
■ Pulse Length	0.350 ms (250 turns)
■ Trans. Emittance(n,rms)	2 pi mm mrad
■ Energy Spread	$\pm$ 0.1 MeV (0.1 %, 95%)
■ Energy Jitter	$\pm$ 0.1 MeV
■ Chopping	Slow + fast

BNL 200 MeV Linac

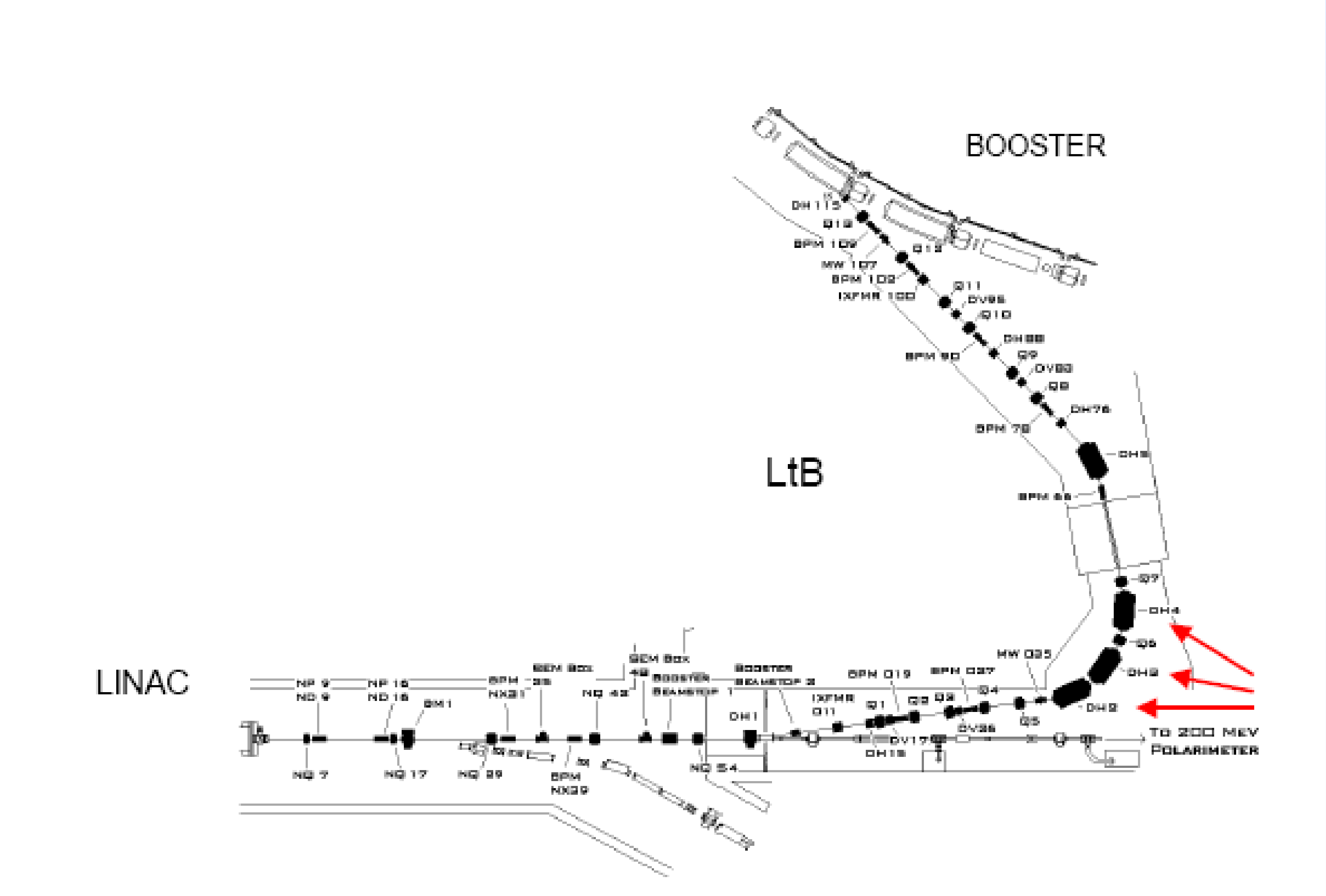
General Parameter of BNL 200 MeV Linac

Preinjector Energy	0.75	MeV
Output Energy	200.3	MeV
Peak Beam Current	100	mA
Emittance (100mA at 200 MeV)	1	pi cm-mrad
Beam Pulse Length (max)	200	µsec
RF Pulse Length	400	µsec
Operating Frequncy	201.25	MHz
Number of Cavities	9	
Total Length of the Accelerator	144.8	meters
Numbers of unit cells	286	
Total Peak RF Excitation Power	22	MW
Pulse Repetition Rate (max)	10	pulse/sec

Linac to Booster Transfer Line (LTB)

- Transport to linac to booster
- Match into booster
- Measure Transverse Beam Quality
- No collimation
- No energy correction
- No buncher cavity
- No chopper in the LTB
- ~ 60 meter long
- 120 degrees bend
- Magnetic stripping of H^- not an issue

Transfer line layout



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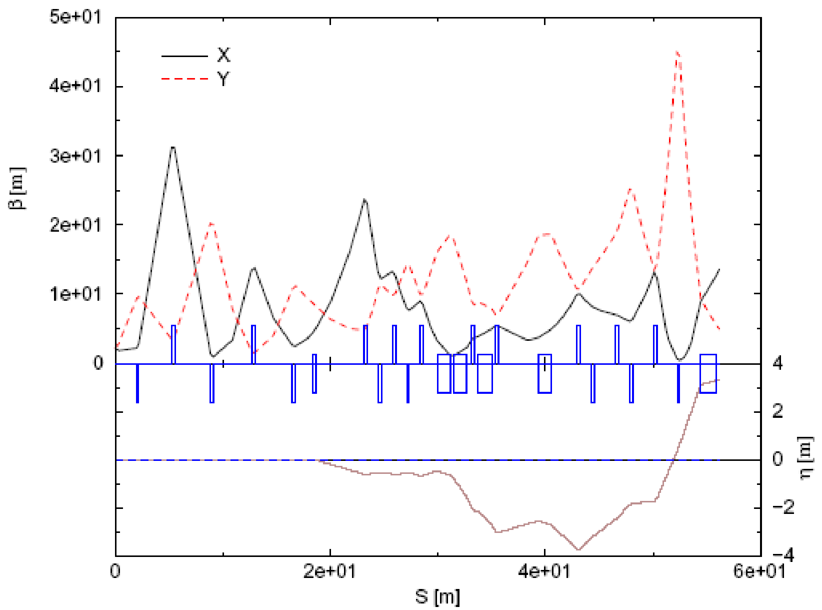
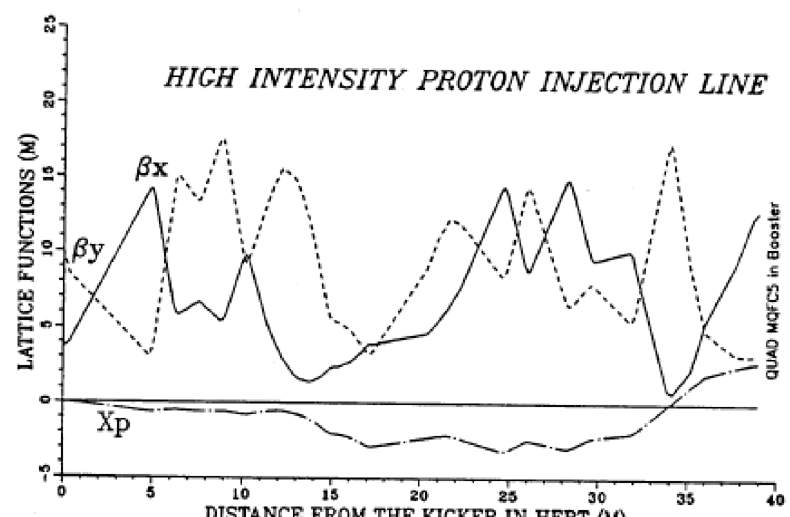
Lattice function in the transfer line



Present mode of operation

As design in 1988



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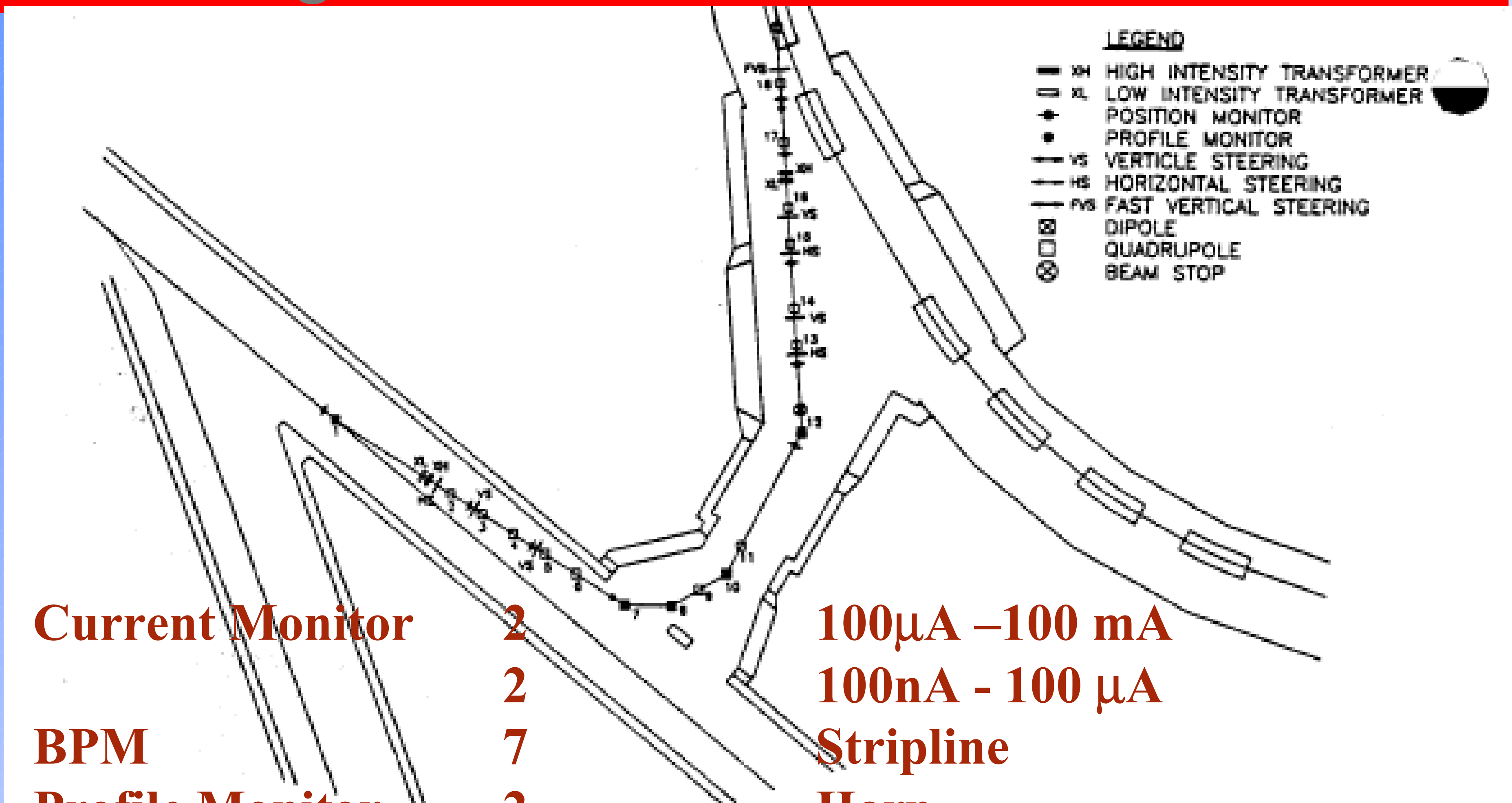
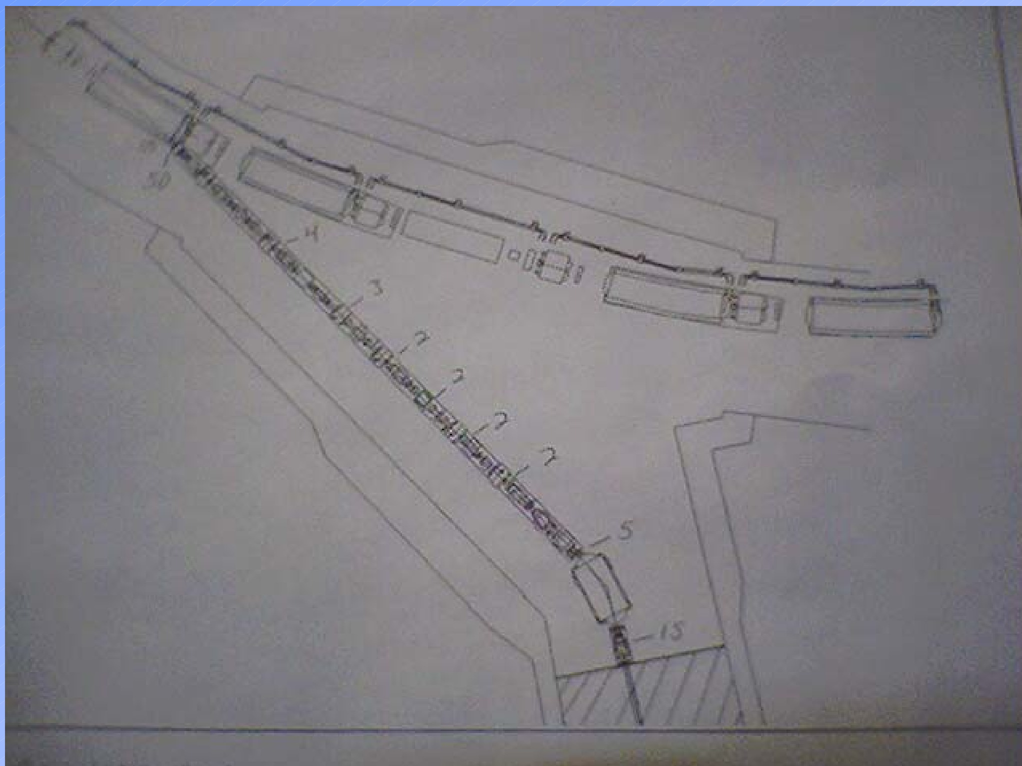
Diagnostics in the transfer line

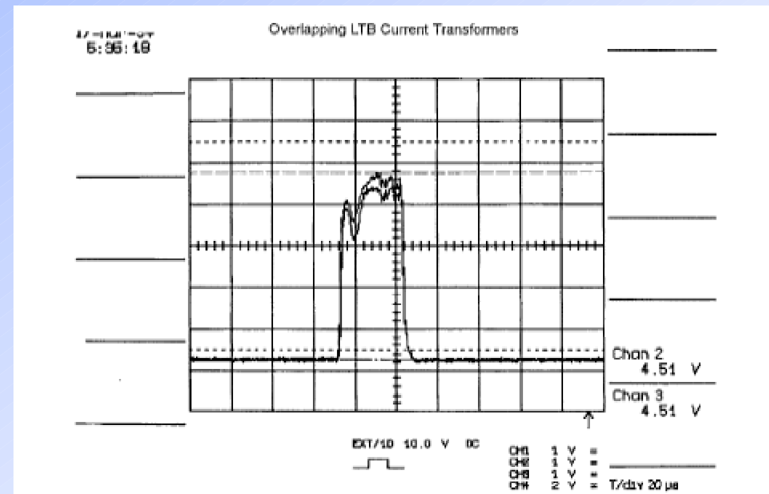


Current Monitor	2	100µA –100 mA
	2	100nA - 100 µA
BPM	7	Stripline
Profile Monitor	2	Harp
Radiation Monitor	8	Ion Chamber

Losses in the LTB

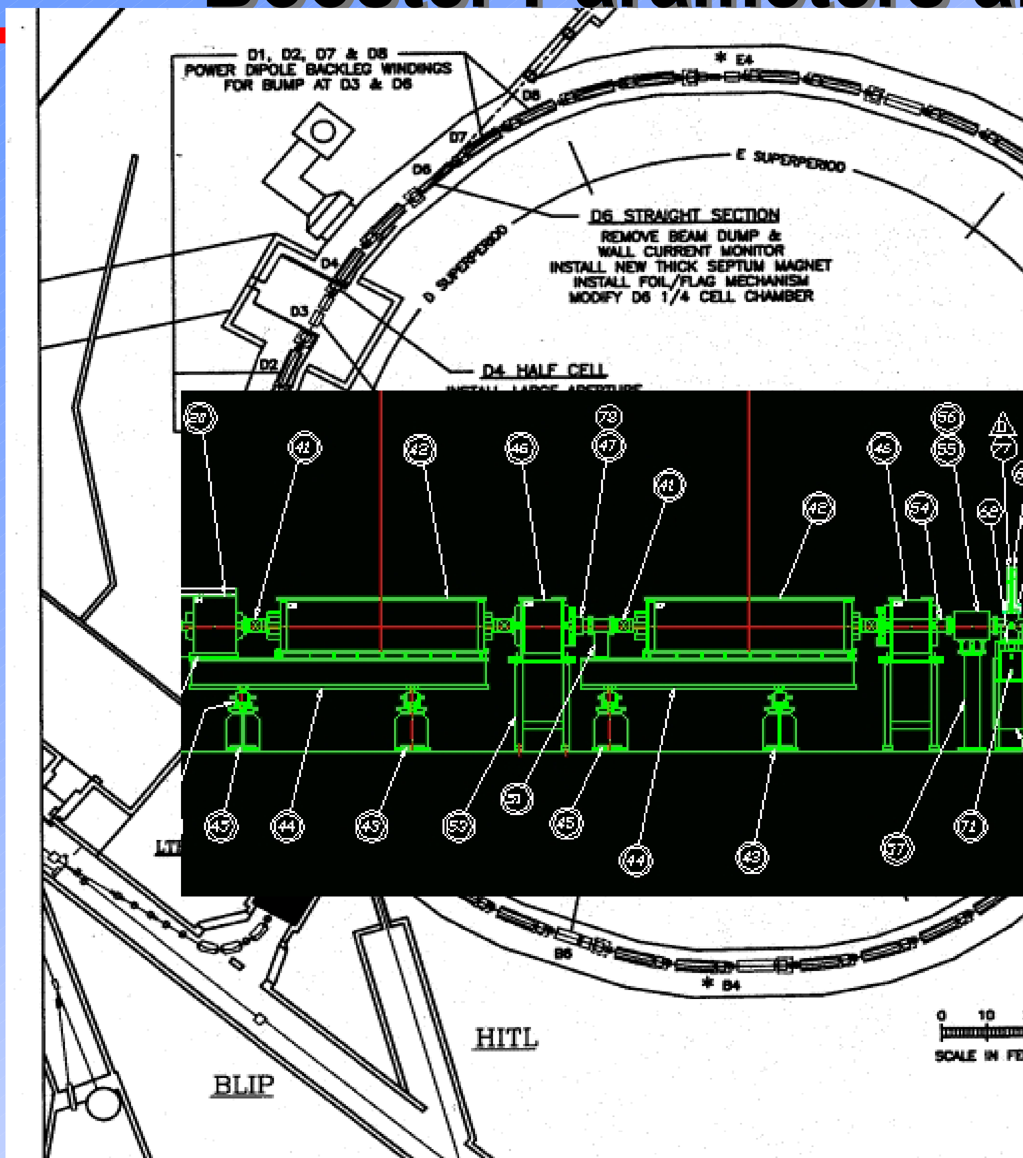


Transmission 90-95%



Current monitor XF011 , XF100

Booster Parameters and Performance



Parameter	Value
Circumference	201.78 (1/4 AGS) m
Ave. Radius	32.114 m
Magnetic Bend R	13.8656 m
Lattice Type	Separated Function, FODO
No. Superperiods	6
No. of Cells	24
Betatron Tunes,X,Y	4.82, 4.83
Vacuum Chamber	70 x 152 mm Dipoles 152 mm (circular) Quads
Max. Rigidity	17 Tm
Injection Rigidity	2.2 Tm (200 MeV protons)
Acceleration Rate	8.9 T/s (7.5 Hz)

Booster & AGS Performance

Imposed limits to lost beam power to maintain hands-on maintenance (ALARA).

■AGS SEB operation, 5.4 s AGS cycle time, 6 Booster cycles.

Achieved 19.6 Tp/sec, Booster Late & 13.7 Tp/second, AGS Late.

Table 1: SEB 10 Pulse Ave. Data (best performance)

* 1 Tp = 1×10^{12} protons

	Intensity (Tp/cycle) *	Efficiency (%)	Beam Loss (Tp/cycle)	ALARA (Tp/cycle)	Loss (kW)	Loss/m (W/m)
Linac	177	-	-	-	-	
Booster Injected	125	71	52	54	0.31	1.5
Booster Extracted	106	86	18	18	0.5	2.5
AGS Injected	78	74	28	31.5	1.62	2.0**
Transition	76	98	2	3	0.26	0.3
After Transition	73	95	3	4.5	0.63	0.8
AGS Late	73	100	0	1.5	0	0

** assumed lost in AGS

Booster & AGS Performance

Imposed limits to lost beam power to maintain hands-on maintenance (ALARA).

■AGS FEB operation, 2.77 s cycle AGS cycle time, 6 Booster cycles

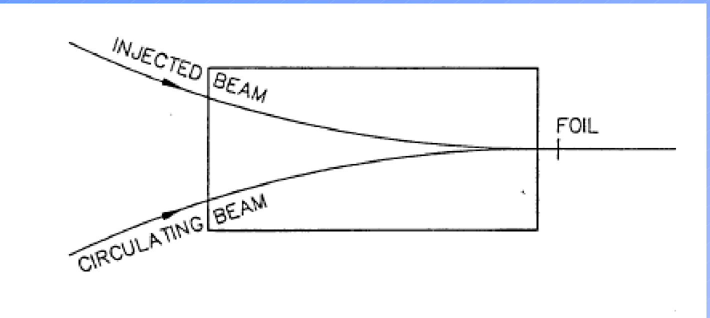
Achieved 30 Tp/sec, Booster Late & 22 Tp/sec, AGS Late

Table 2: FEB 10 Pulse Ave. Data (best performance, not sustainable operation)

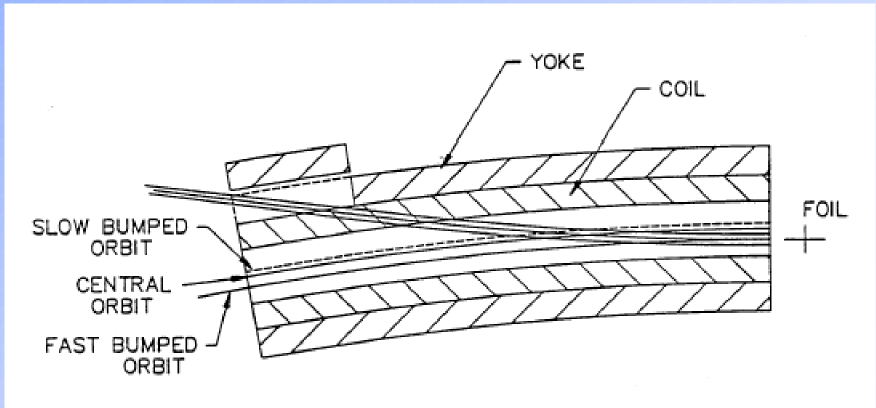
	Intensity (Tp/cycle)	Efficiency (%)	Beam Loss (Tp/cycle)	ALARA (Tp/cycle)	Loss (kW)	Loss/m (W/m)
Linac	115	-	-	-	-	-
Booster Injected	89	77	27	27.7	0.31	1.5
Booster Extracted	83	93	6	9.2	0.33	1.6
AGS Injected	66	78	18	16.3	2.0	2.5**
Before Transition	62.3	94	3.7	1.5	0.9	1.1
After Transition	61.6	99	0.6	2.3	0.2	0.2
AGS Late	61.4	99.5	0.3	0.8	0.25	0.3

** assumed lost in AGS

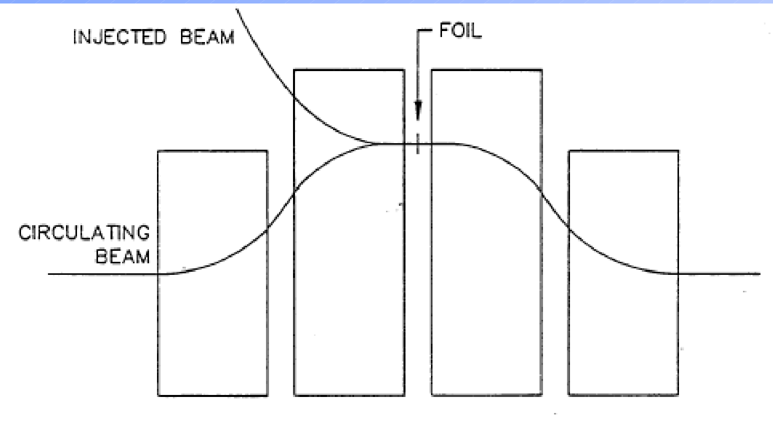
H- Injection



Charge exchange foil location
Downstream of dipole



Injection in dipole magnet (C5) through yoke



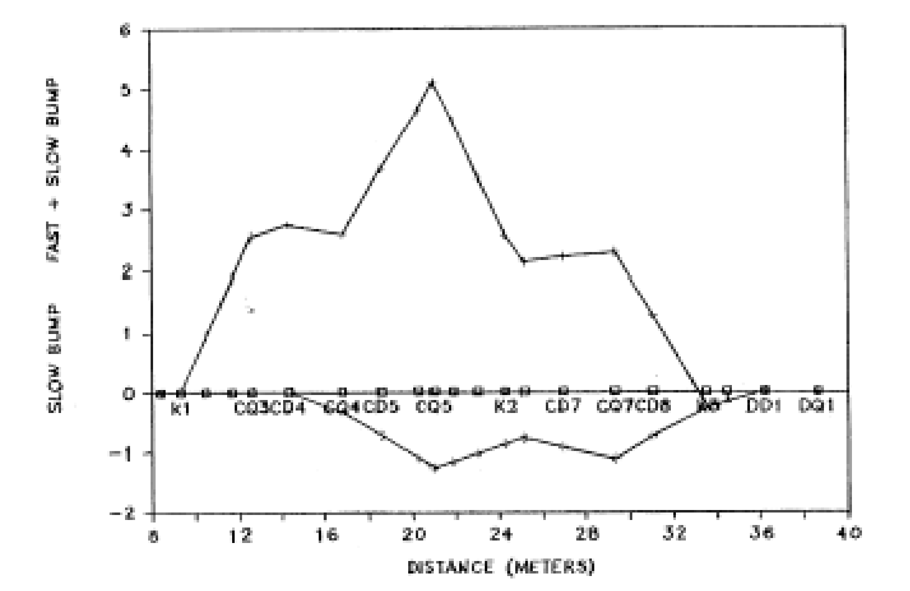
Foil	carbon
Foil thickness	200 μg/cm^2

No beam dump for H0, H-
No stripped electron collector

Bump in the circulating beam at
Injection to reduce multiple foil hit

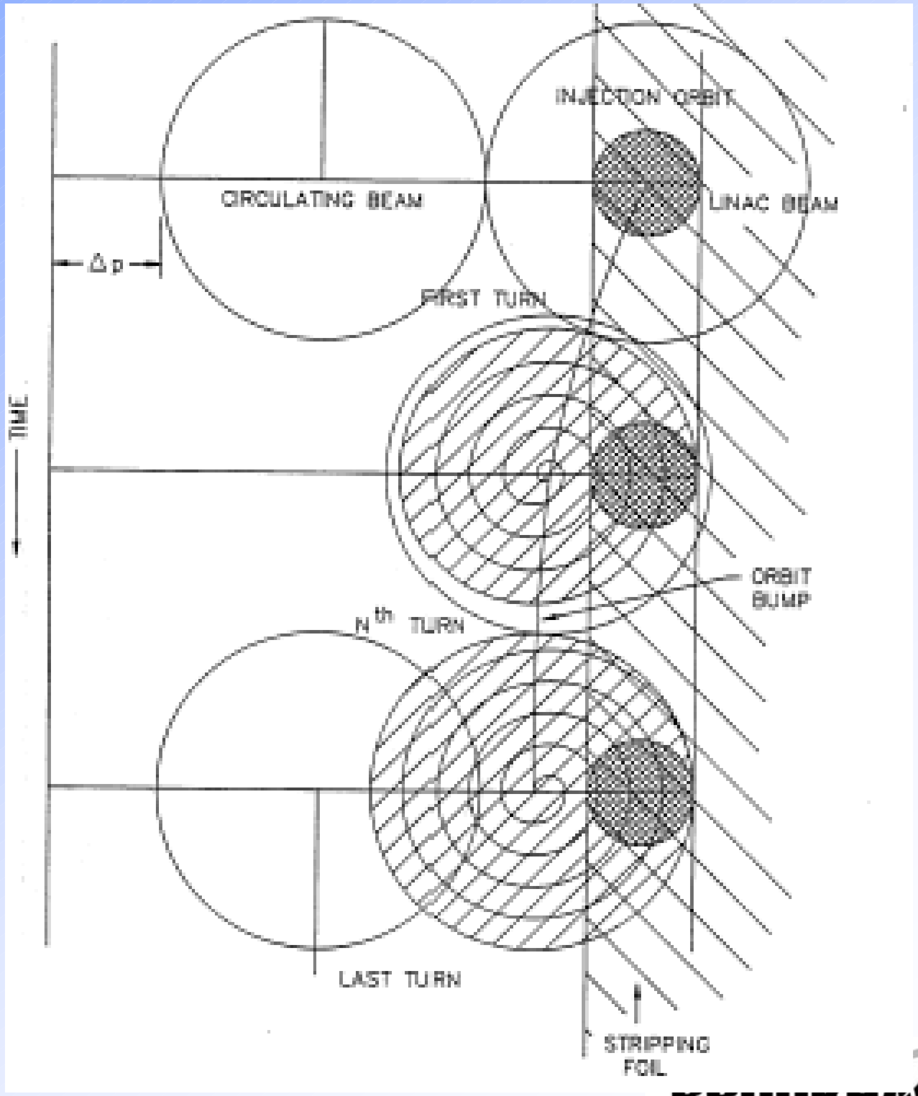
Slow and Fast Bump

	Loc.	Rad
Slow Orbit Bump1	C4	0.00136
Slow Orbit Bump2	C8	0.00039
Slow Orbit Bump3	D1	0.0094
Foil	C5	
Injection Kicker1	C3	0.007889
Injection Kicker2	C6	0.002609
Injection Kicker3	C8	0.008153



Painting In H-plane only

Painting in H-plane only
Smoke ring in y-plane



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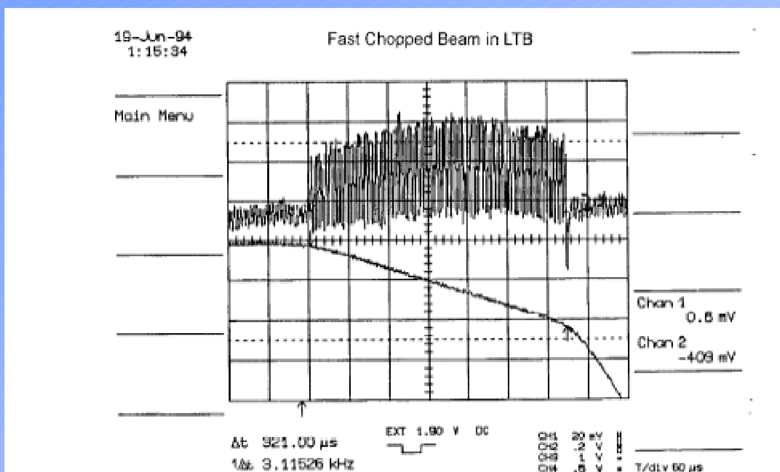
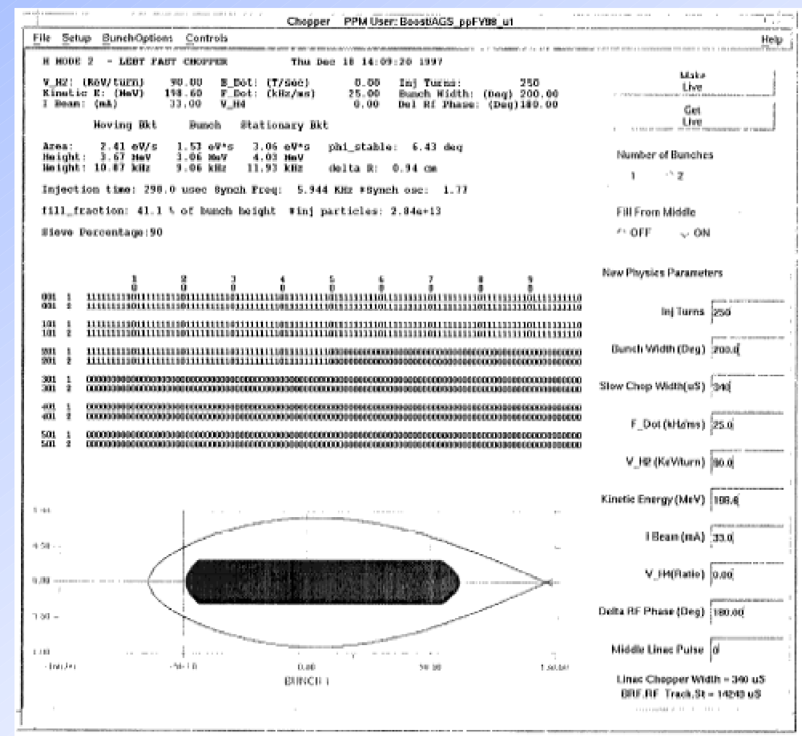
Longitudinal

Slow chopper in MEBT
Fast Chopper in MEBT

Macropulse
Micropulse



Top trace BPM019,
Bottom trace current in D1



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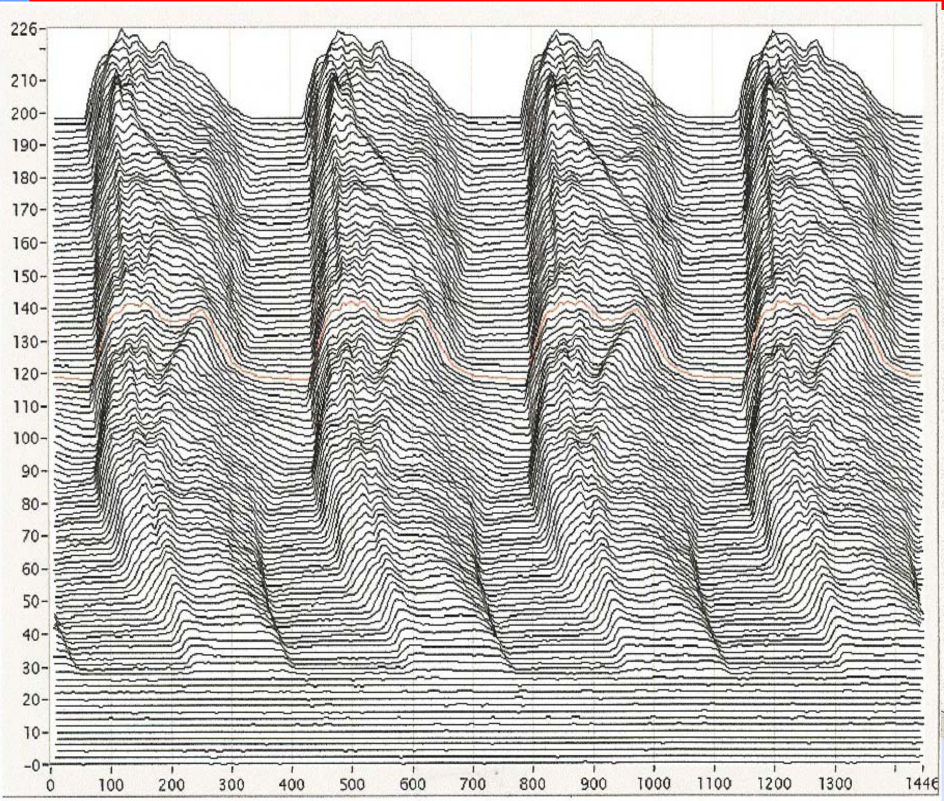
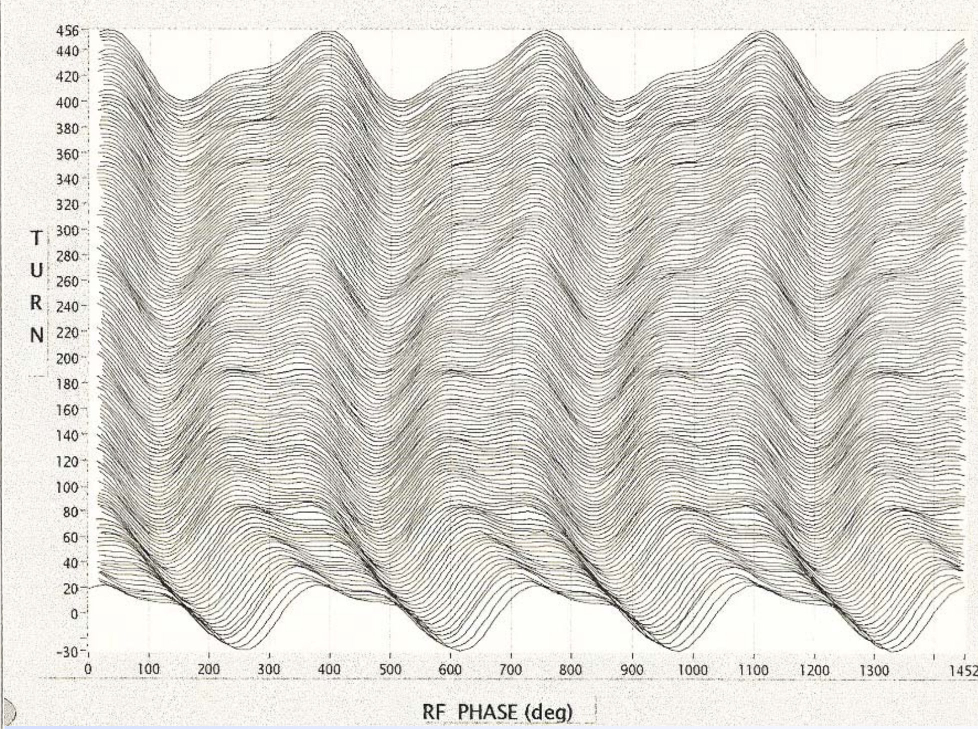
Line Density from Wall Current monitor

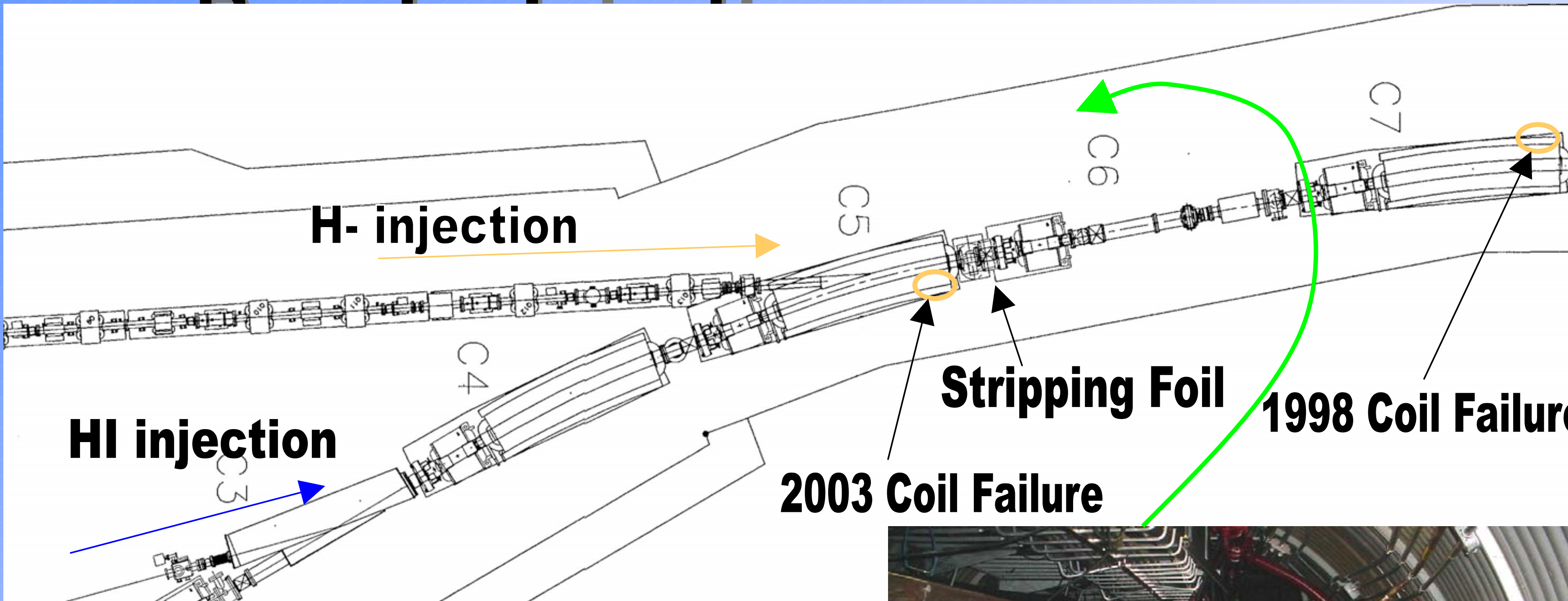


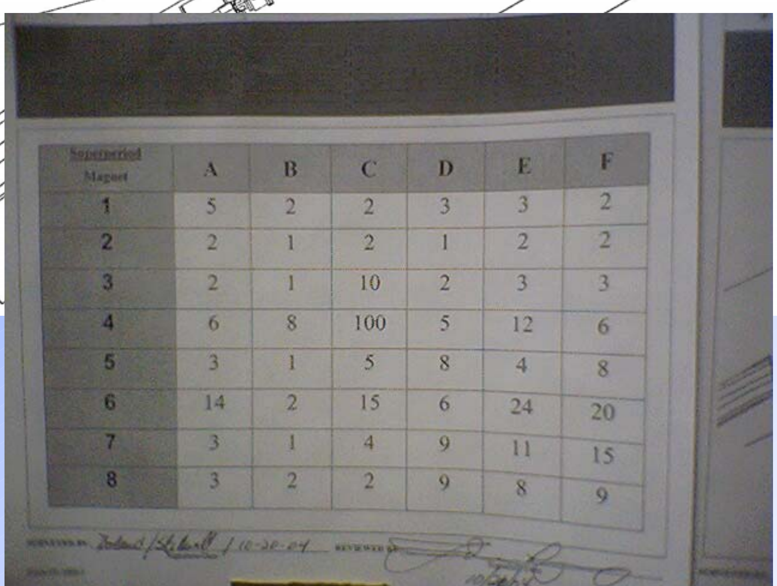


Line density from wall current monitor.

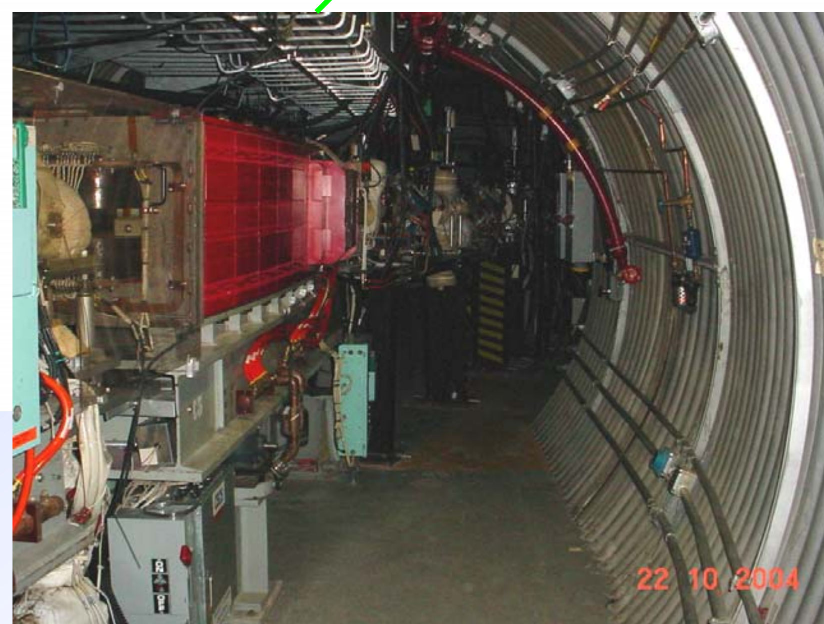
h=1+2, RF capture at injection. 4 turns per sweep.

RF gap volts sum. 1st and 2nd harmonic cavities at injection during RF capture.





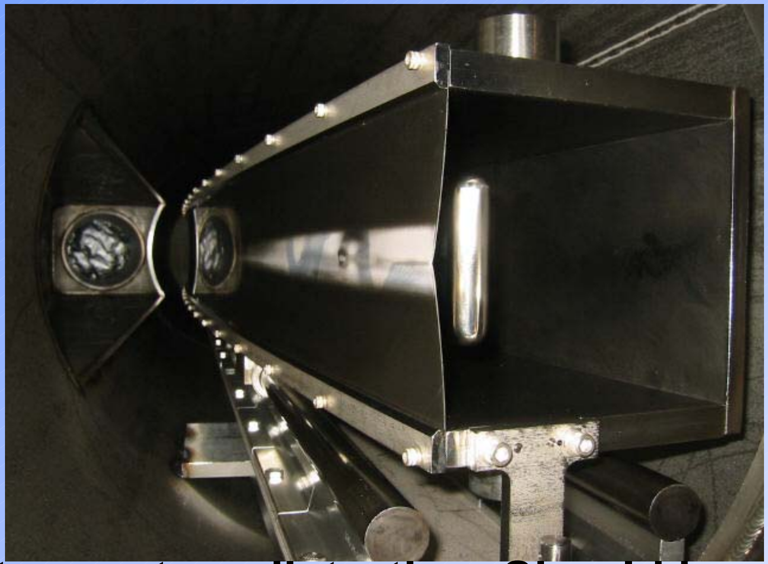
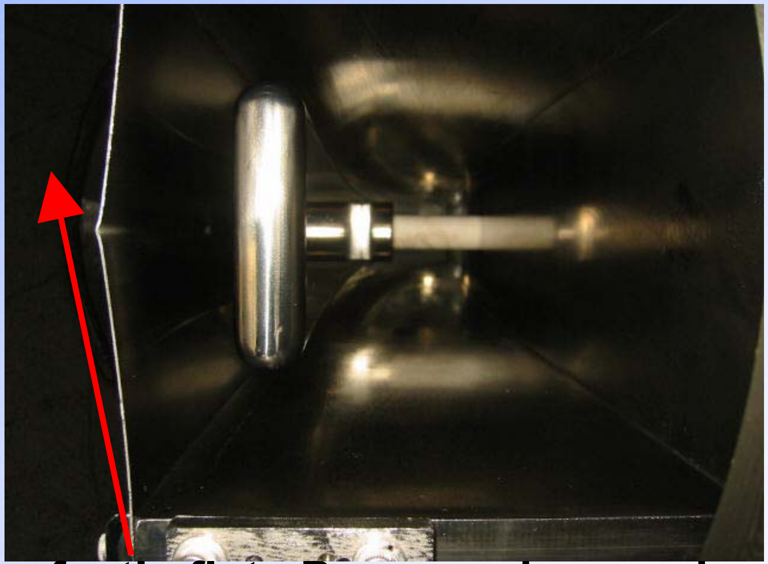
Superperiod / Magnet	A	B	C	D	E	F
1	5	2	2	3	3	2
2	2	1	2	1	2	2
3	2	1	10	2	3	3
4	6	8	100	5	12	6
5	3	1	5	8	4	8
6	14	2	15	6	24	20
7	3	1	4	9	11	15
8	3	2	2	9	8	9



Booster Injection

- Reducing the risk of a C7 magnet failure
  - Thicker H- stripping foil. Will reduce H^0 to less than 0.3 %
    - 200 μgm = 0.4 %
    - 250 μgm = 0.09 %
    - Main Issue is emittance growth
  - Add Carbon Block absorber in Quad Upstream of C7, located to catch H^0
    - Main Issue is does this significantly reduce acceptance?
- Reducing the risk of a C5 magnet failure
  - Restrict acceptance of transfer line, to prevent beam scraping at entrance to C5 (collimation in transfer line)
    - assumes cause is beam scraping at or near the entrance
  - Add Carbon Block between vacuum chamber and coils on inside of C5 magnet, to diffuse and absorb lost particles.

C3 Inflector Protection

Inflector septum distortion. Should be perfectly flat. Presumed cause is high intensity protons scraping on the septum.

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Conclusions

1. LTB transport, diagnosis and matches into the booster
2. No energy correction, debuncher or collimator
3. Transmission 90-95%
4. H-plane painting only, Y-plane smoke ring
5. Injection efficiency 75-80%